Sound Transit Central Link Light Rail, Public Address System

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Sound Transit Central Link Light Rail Project

- Current downtown BRT underground stations being upgraded to serve BRT and light rail vehicles
- Several all new elevated and at-grade light rail stations being constructed

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ST Central Link Light Rail System Map

Current Initial Segment from downtown south to near airport (including existing BRT stations)

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PA System Design Challenges

- Strict interpretation of NFPA 72, National Fire Alarm Code
- High anticipated background noise levels
- Large, hard spaces
- Significant architectural constraints regarding speaker size and placement

NFPA 72 Requirements for Emergency Communications Systems

- Speech Transmission Index (STI) >.55
- SPL at least 15 dB above ambient level; 70 dB minimum, 120 dB maximum

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Sound Transmission Index (STI)

- Index value between 0-1 used to quantify speech intelligibility
- Factors influencing STI
  - Sound Power
  - Reverberation Time
  - Background Noise Level
  - Room Shape

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Sound Transmission Index (STI)

STI Value	*Speech Intelligibility*
0.6 – 1.0	Very good
0.45 – 6	Good
0.3 – 0.45	Poor
0.0 – 0.3	Unacceptable

Measured Reverberation Times

1/3 Oct. Band Center Freq. (Hz)	*Reverberation Time (seconds)*				
	International	*Pioneer Sq.*		*University*	*Westlake*
	platform	*platform*	*mezzanine*	*platform*	*platform*
200	3.6				
250	3.0	3.5	1.5		3.0
315	3.5	3.2	1.9		2.9
400	3.2	4.3	2.3	2.8	2.5
500	3.9	3.5	1.9	2.3	2.7
600	4.1	2.8	2.2	2.2	2.5
800	4.1	2.8	2.1	2.1	2.6
1000	3.2	3.0	2.1	2.7	2.8
1250	3.2	3.0	2.0	2.6	2.4
1600	3.1	3.0	1.9	2.4	2.4
2000	3.0	2.8	2.0	2.4	2.3
2500	2.7	2.5	1.9	2.4	2.1
3150	2.3	2.6	1.7	2.1	1.9
4000	1.9	2.1	1.5	1.8	1.6
5000	1.6	1.7	1.1	1.6	1.3
6000	1.2	1.3	0.9	1.2	1.1
8000	0.9	1.0	0.8	0.8	0.8
10000	0.7	0.7	0.6	0.6	0.6

Ambient Noise Levels

(Typical Measured Sound Levels)

Location/Source	*Leq (dBA)*	*Lmax (dBA)*
Underground Stations, Ambient (Existing BRT, 5 min sample)	65 – 75	75 – 85
Above Ground Stations, Ambient (Existing street traffic, 5 min sample)	65 – 75	75 – 85
Underground Stations, Discrete Events (Existing BRT, 10 sec. sample)	70 – 75	80 – 85
Underground Stations, Discrete Events (Existing LRT, 10 sec. sample)	75 – 85	80 – 90
Above Ground Stations, Discrete Events (Existing LRT, 10 sec. sample)	65 – 75	75 – 85

PA System Design Concepts

1. Well placed, high quality speakers
2. Highly distributed reinforcement system
3. Employ automatically adjusting levels that take into account background level
4. Augment/integrate with visual paging
5. Employ appropriate noise control and acoustical absorption

PA System Design Constraints

1. Speaker placement dictated by Architect
2. High ambient sound levels (predicted by the Owner)
3. Owner reluctance to add acoustical absorption

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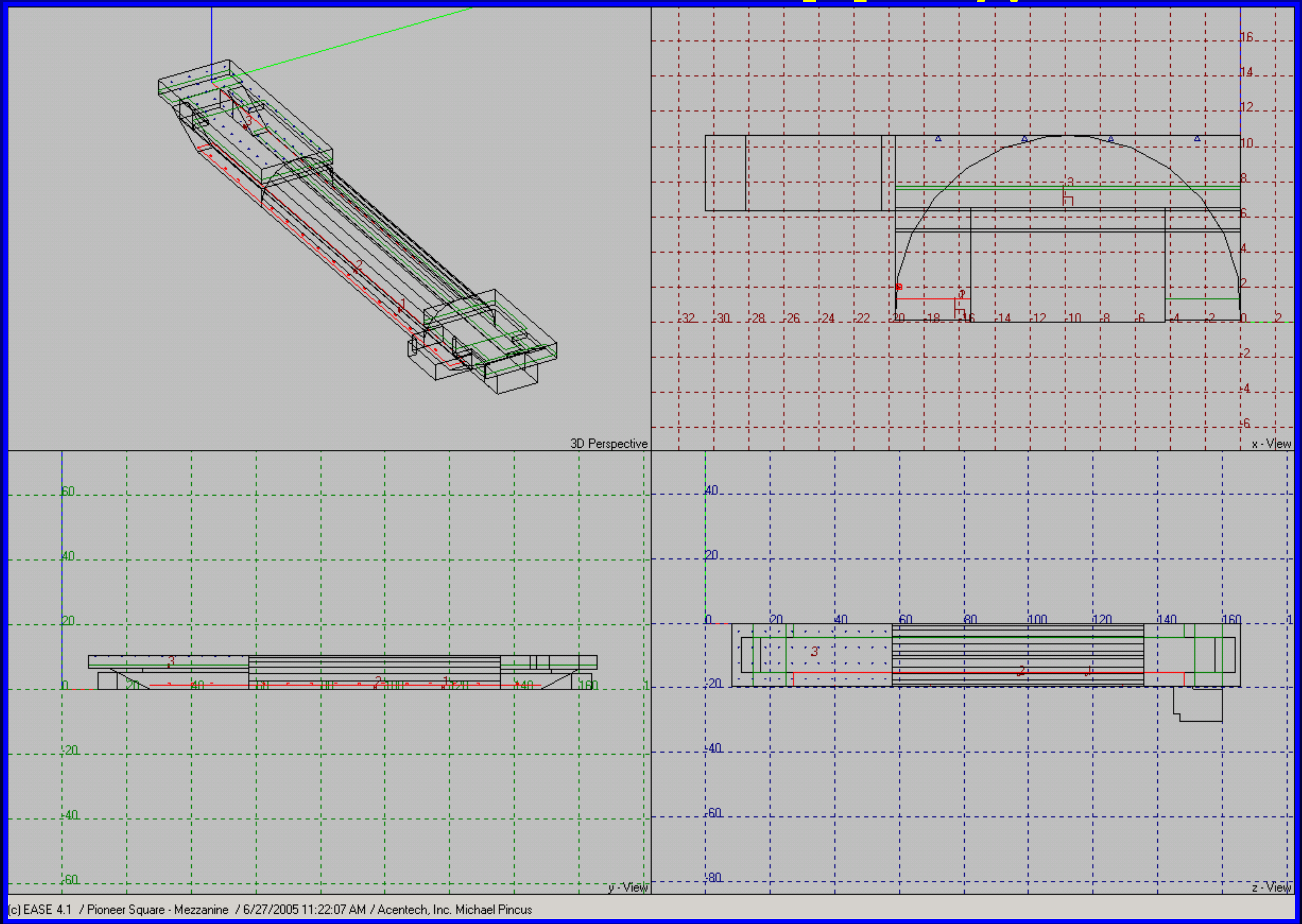
System Design Tools

3D Computer Modeling:

- Simulate architectural/acoustic environment
- Predict system performance - mappings
- Auralization - simulate performance aurally

Models & Mappings



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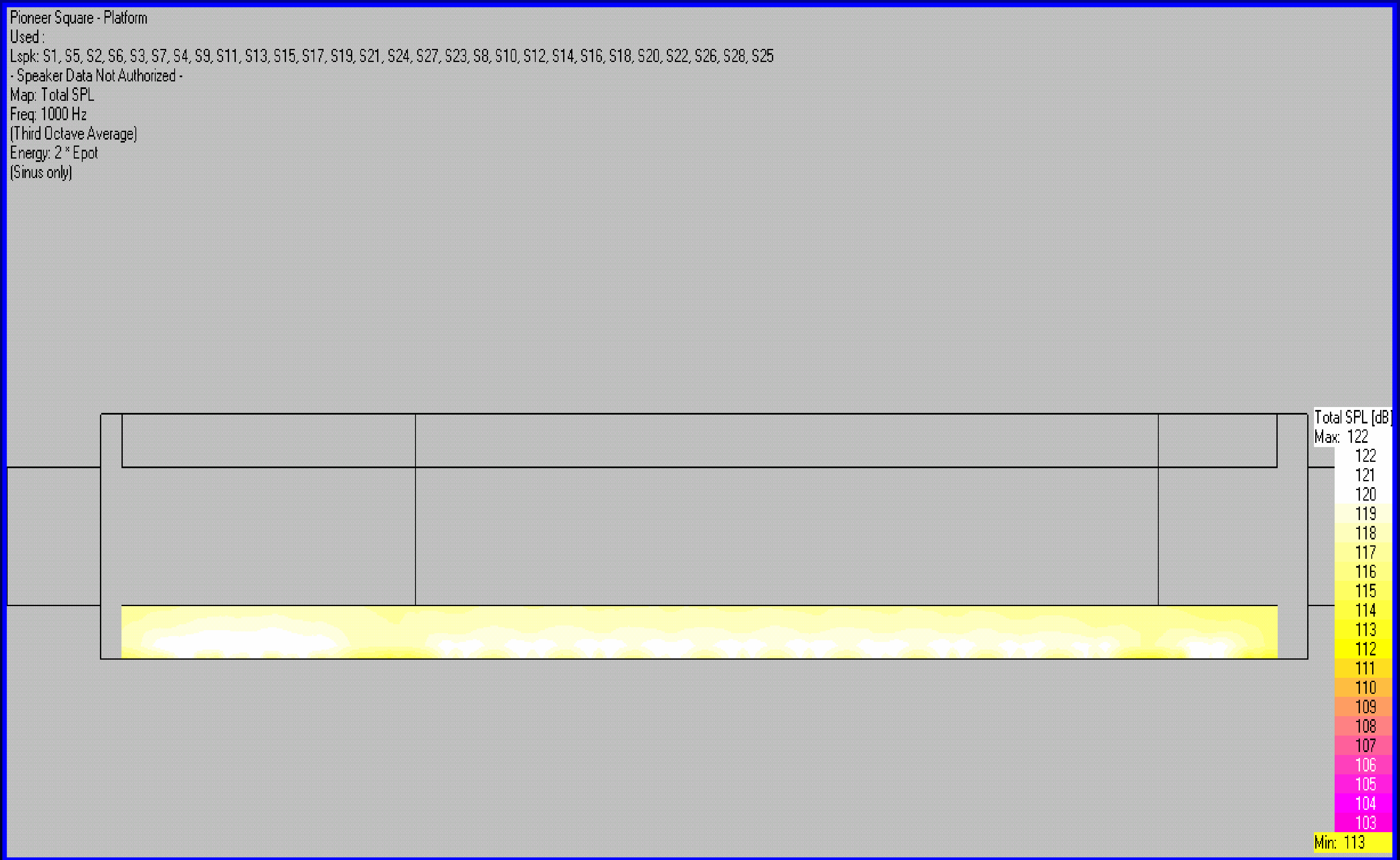
Models & Mappings



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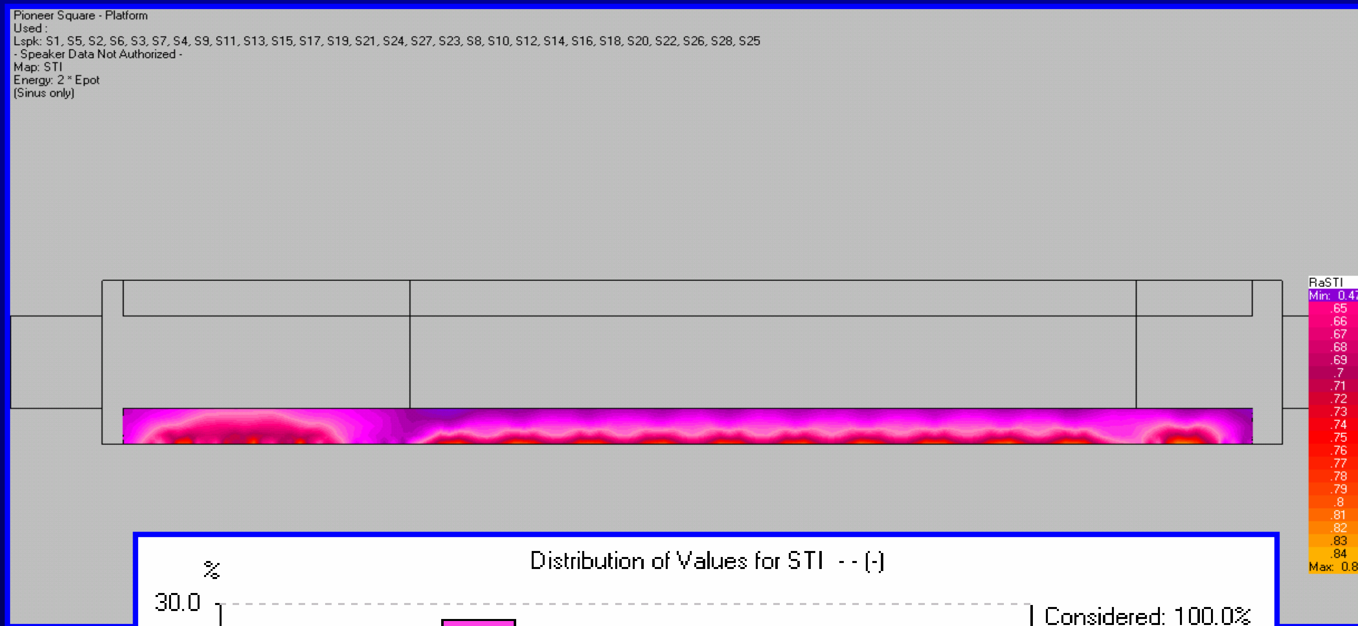

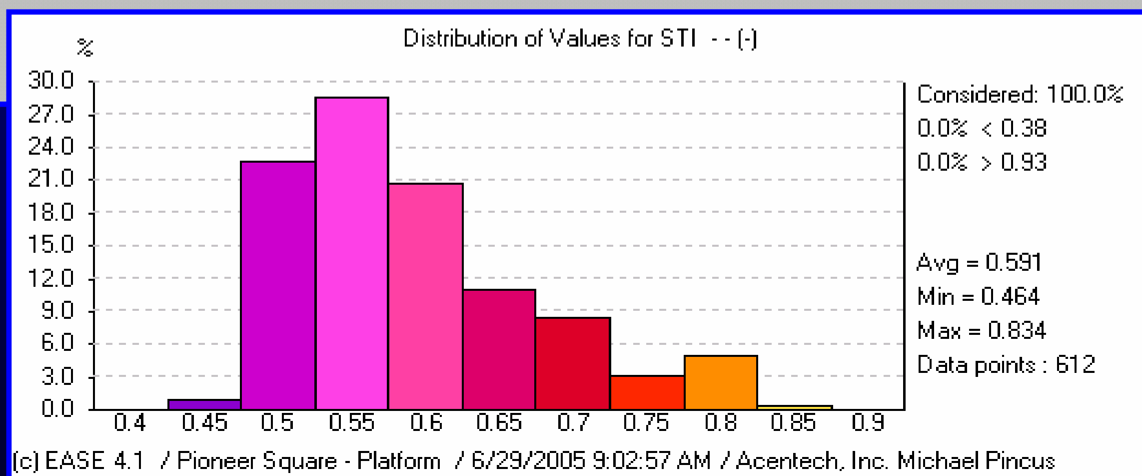

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Advanced Techniques

Use of powerful computer models and simulations:

- Predict STI per IEC 60268-16
- Simulate system performance aurally with advanced binaural response and convolution algorithms

Conclusions

- Cavernous, hard station environments presented challenging PA system design task.
- Project constraints with respect to acoustical and PA system design options further limited system performance.
- Computer analysis predictions suggest that in most cases PA system will just marginally satisfy project requirements, but still a substantial improvement over the existing system.